1972 Ozone Depletion Calculations

Photo credit: The Boeing Company

Depletion of stratospheric ozone was one of the concerns raised when development began of commercial supersonic transport aircraft. Later, use of chlorofluorocarbons was prohibited because of similar concerns about ozone depletion.

Preventing Planetary Sunburn

In 1972, the Laboratory applied newly developed modeling capabilities to investigate whether human activities might degrade the stratospheric ozone layer, which screens out most of the radiation that causes sunburns and skin cancer. U.S. decision-makers needed information on the potential effects of a proposed fleet of supersonic transports (SSTs)—faster-than-sound commercial jet aircraft—that would fly in the stratosphere. Concerns were raised that exhaust emissions might chemically react in ways that would thin the stratospheric ozone layer. Livermore's one-dimensional (altitude) model of stratospheric ozone, developed under Julius Chang, was one of the first simulation tools in the world used to examine ozone interactions with the SST's nitrogen oxide emissions.

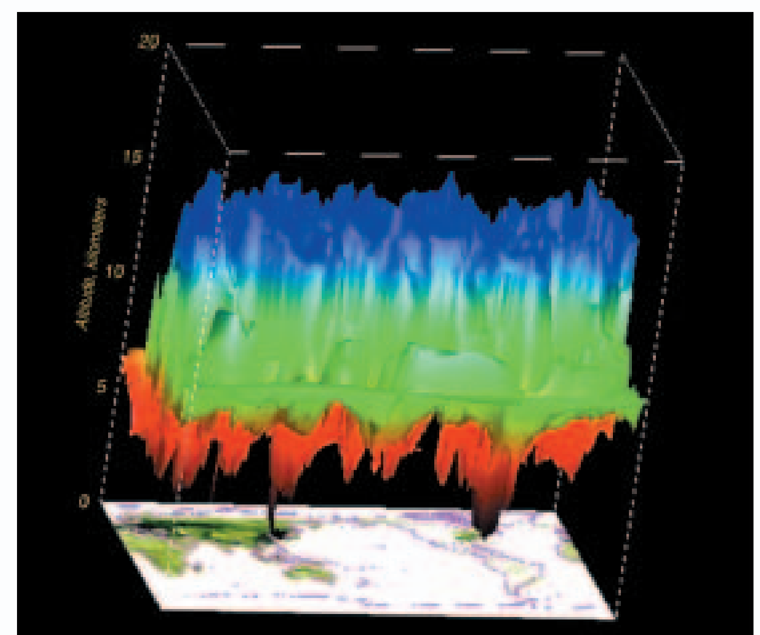
An important early test of the model was its ability to explain the observed decrease in stratospheric ozone concentrations following atmospheric nuclear testing by the United States and the Soviet Union in the early 1960s (see Year 1962). These simulations clearly indicated that use of a large number of megaton-size nuclear weapons in a nuclear war would seriously deplete stratospheric ozone—in addition to the extensive destruction caused at the surface. This finding later played a central role in a 1974 National Academy of Sciences study on the potential long-term world-wide effects of multiple nuclear weapons detonations, adding impetus for the two superpowers to reduce weapon yield and the size of their nuclear arsenals.

In 1974, the effect of chlorofluorocarbon (CFC) emissions on stratospheric ozone also became an issue. In response, Don Wuebbles and colleagues at the Laboratory developed a two-dimensional (latitude and altitude) model that predicted increasingly severe ozone depletion from continued use of CFCs in aerosol spray cans, refrigerators, and air conditioners. These results provided important input to the first international assessment of stratospheric ozone. International negotiations to limit CFCs ensued, and the U.S. prohibited their use as propellants in spray cans. Later, the research team developed a technique for calculating the Ozone Depletion Potential (ODP) of other compounds, a formulation that was included in the Montreal Protocol. Adopted in 1987, the protocol set goals for globally phasing out the use of halocarbons that have high ODP.

As computers became more powerful, Laboratory researchers developed three-dimensional global simulation capabilities and began analyzing the details of chemical reactions involving airborne aerosols (particles). Because of the Laboratory's scientific expertise and large-scale computing capabilities, Livermore now serves as the Core Modeling Team for the NASA Global Modeling Initiative.

Less Bay Area Ozone

In the late 1960s, the Laboratory responded to a growing interest in the quality of our environment by applying its capabilities to help understand human-induced affects on the atmosphere. The rising number of excess ozone days in the Livermore Valley prompted Mike MacCracken and colleagues to adapt a new modeling technique developed at the University of Illinois for use as the core of a Bay Area air-quality model. Results from this model and later versions served as the basis for preparing the Bay Area's Air Quality Maintenance Plan, which, with later revisions, has lowered the number of days of excess ozone from about 50 per year to just 1 or 2 per year.



Livermore researchers continue to improve the air chemistry models in simulations of atmospheric circulation. The transport of ozone from the lower stratosphere to near-surface altitudes is studied using models that require the Laboratory's supercomputers.